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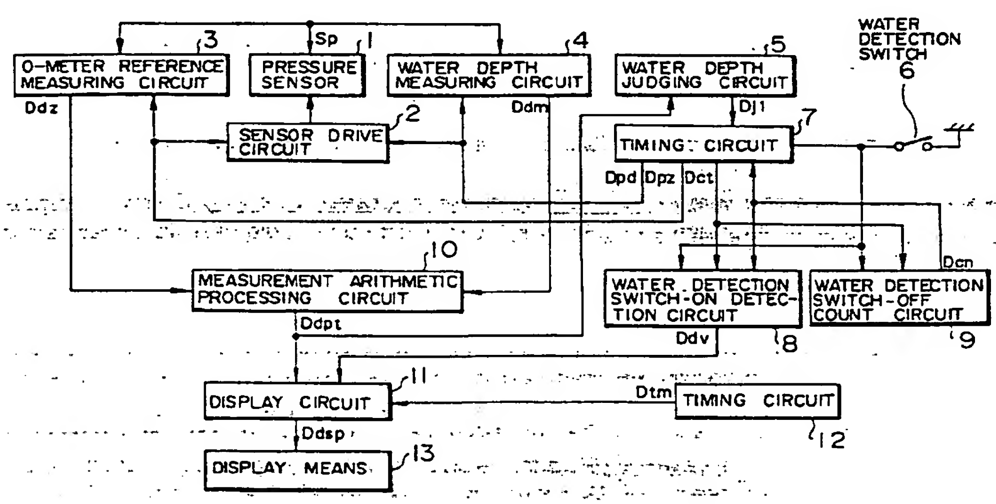
(54) Electronic watch having a water depth measuring function

(57) The present invention is aimed to propose a method for minimizing erroneous shift to a water depth measurement mode by judging whether shift to a water depth measurement mode is caused by normal operation or erroneous detection and for automatically getting out of the water depth measurement mode even in the case of erroneous shift to the water depth measurement mode. Instantaneous shift to a water depth measurement mode is prevented when the water depth judging circuit 5 judges that a water depth value Ddpt from the measurement arithmetic processing circuit exceeds a predetermined value and that the water detection switch 6 detects no water contact, and a time information display mode is automatically returned even in the case of erroneous shift to a water depth measurement mode. Instantaneous shift to a water depth measurement mode is prevented when the water detection switch is on under conditions other than diving, and an original mode is automatically returned by judging the situation precisely even in the case of unexpected shift to a water depth measurement mode.

FIG. 1



EP 0 745 915 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an electronic watch having a water depth measuring function. More specifically, it relates to an operation technique for preventing erroneous detection in an electronic watch having a water depth measuring function.

2. Description of the Prior Art

Heretofore, there has been proposed an electronic watch having a water depth measuring function which comprises an external terminal electronically insulated from a casing and means for detecting water contact from electrical conduction between this terminal and the casing through water so as to automatically starts water depth measurement.

The applicant has proposed in WO94/20886 that measurement of a water depth of 0 m as a reference is made at intervals of a fixed time for water depth measurement, water depth measurement is started when water contact is detected with water contact detection means such as one described above, it is detected that a diver is under water when a water depth of more than 1 m is measured, and the operational ease of the diver is improved by shifting to an underwater measurement mode.

However, if this technique in which measurement of a water depth of 0 m as a reference is made at intervals of a fixed time for water depth measurement, that is, atmospheric pressure on the ground is measured at intervals of 5 minutes, an atmospheric pressure at that time is stored as a value for a water depth of 0 m, and water depth measurement is made based on this reference value for a water depth of 0 m when water contact is detected by the above water contact detection means is adopted in an electronic watch having a water depth measuring function, it is obvious that water depth measurement is based on pressure data obtained when the water depth is 0 m. Therefore, it is desirable that the accuracy of water depth measurement should be increased by measuring a water depth of 0 m as a reference right before diving and a water depth of 0 m should be measured as a reference in a very short period of time, which is disadvantageous in terms of power consumption. Meanwhile, when this interval is extended, for example, to 1 hour, the following problems are produced.

That is, although atmospheric pressure inside the airplane is adjusted during flight at an altitude of several thousands of meters above the ground when a user is on board the airplane, the difference of atmospheric pressure between the ground and the airplane is about 2,000 m in terms of altitude. Therefore, measurement of a water depth of 0 m as a reference is made in the sky. Before the next chance of measuring a water depth of 0 m as a reference after landing on the ground, water depth measurement is carried out by creating a wet state for the above water contact detection means by some operation such as perspiration or the like. At this point, when a predetermined water depth, for example, a water depth of more than 1 m, is measured from the difference of atmospheric pressure from the previous measurement value for a water depth of 0 m as a reference, it is erroneously detected that the diver dives under water. This results in display lock in an underwater measurement mode, restrictions imposed on functions, and an increase in power consumption caused by water depth measurement, which are fatal problems to an electronic watch having a water depth measuring function which uses a small battery as a main power source.

Because of the above restrictions, measurement of a water depth of 0 m as a reference is made every 5 to 10 minutes. However, it is impossible to completely eliminate erroneous shift to an underwater measurement mode due to an unexpectedly large change in atmospheric pressure. To return from the erroneously detected mode to the original mode, there has been proposed to forcedly operate the switch to return to the original mode. However, when the diver is unaware of this, the battery is used up in the worst case. When the original mode is returned by some means or other, the diver may be confused temporarily.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an electronic watch having a water depth measuring function, which eliminates the above defects, judges properly whether a water depth measurement mode is caused by proper operation or by erroneous detection, and is controlled such that it automatically gets out of a water depth measurement mode when it is caused by erroneous detection or it is not shifted to a water depth measurement mode.

To solve the above problems, the present invention provides an electronic watch having a water depth measuring function, which comprises water detection means for detecting contact with water or sea water, a timing circuit for generating a timing signal for measurement or the like, a pressure sensor, a water depth measurement circuit for measuring a water depth based on a water pressure detected by the pressure sensor, and water depth judging means for judging that the water depth exceeds a predetermined value, wherein the watch further comprises water detection switch count circuit for detecting that the water detection means generates an off signal for a predetermined time while the water depth judging means is supplied with a signal indicating that the water depth exceeds the predetermined value.

Further, even when the water depth exceeds a predetermined during water depth measurement at the

time of the detection of water and when the water detection means generates an off signal a predetermined number of times for sampling at the time of the next water detection sampling, shift to water depth display is cancelled.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an electronic watch having a water depth measuring function according to a first embodiment of the present invention, FIG. 2 is a timing chart explaining the operation of the first embodiment of FIG. 1, FIG. 3 is a flow chart explaining the operation of the first embodiment of FIG. 1, FIG. 4 is a sectional view of an electronic watch having a water depth measuring function according to a second embodiment of the present invention, and FIG. 5 is a sectional view of an electronic watch having a water depth measuring function according to a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

FIG. 1 is a block diagram of an electronic watch having a water depth measuring function according to a first embodiment of the present invention wherein malfunction of the electronic watch is systematically prevented.

In FIG. 1, reference numeral 1 represents a pressure sensor for outputting a pressure signal Sp which is in proportion to a pressure P, 2 a sensor drive circuit for driving the pressure sensor 1 by supplying a constant current, 3 a 0-meter reference measuring circuit for outputting a zero reference signal Ddz which is a 0-m reference value obtained by measuring an atmospheric pressure signal Sp on the surface of the water, 4 a water depth measuring circuit for outputting a water depth signal Ddm which is a water depth value obtained by measuring a water pressure signal Sp in the water, 5 a water depth judging circuit for outputting a water depth judging signal Dj1 when it detects a predetermined water depth, for example, 1 m or more, and 6 a water detection switch for detecting contact with water or sea water.

The timing circuit 7 outputs a zero reference measurement start signal Dpz which is a timing signal for measuring a 0-m reference value every 5 minutes when the water detection switch 6 is off (when the watch is not in contact with water or sea water). The timing circuit 7 also outputs outputs a water depth measurement start signal Dpd which is a timing signal for measuring a water depth every 1 second when the water detection switch 6 is on (when the watch is in contact with water or sea water). Further, the timing circuit 7 supplies a water detection switch sampling signal Dct, which is provided every 1 second, to the water detection switch-on detection circuit 8 and the water detection switch-off count circuit 9 upon receipt of the water depth judging signal Dj1. Further, the timing circuit 7 cancels the output of the water depth measurement start signal Dpd and the water detection switch sampling signal Dct and starts outputting a zero reference measurement start signal Dpz every 5 minutes upon receipt of a cancel signal Dcn from the water detection switch-off count circuit 9 to . This timing circuit 7 corresponds to circuit operation control means in claims.

The water detection switch-on detection circuit 8 supplies to a display circuit 11 a water depth mode signal Ddv for switching display by the display circuit 11 to a water depth display value based on a water depth value Ddpt when the water detection switch 6 is on after it is supplied with a water detection switch sampling signal Dct from the timing circuit 7. The water detection switch-off count circuit 9 detects the on/off operations of the water detection switch 6 at a timing of a water detection switch sampling signal Dct from the timing circuit 7, counts the number of the off operations, and outputs a cancel signal Dcn for stopping the operations of the timing circuit 7 and a measurement arithmetic processing circuit 10 to terminate water depth measurement when it counts a predetermined number of times, for example, 256 times.

Reference numeral 10 represents a measurement arithmetic processing circuit for computing a water depth based on a zero reference signal Ddz from the 0-m reference measuring circuit 3 and a water depth signal Ddm from the water depth measuring circuit 4 and for outputting a water depth value Ddpt, 11 a display circuit for outputting a display signal Ddsp based on a time signal Dtm from a timing circuit 12 and a display signal Ddsp based on the water depth value Ddpt upon receipt of a water depth mode signal Ddv, 12 a timing circuit for counting time and outputting a timing signal Dtm, and 13 display means for displaying based on the display signal Ddsp.

The electronic watch having a water depth measuring function which has the above circuit configuration operates as follows.

The timing circuit 7 monitors the input state of the water detection switch 6 and supplies a zero reference measurement start signal Dpz to the sensor drive circuit 2 and the 0-m reference measuring circuit 3 every 5 minutes as shown in the timing chart of FIG.2 when the water detection switch 6 is off, that is, a diver is above water. Thereby, the pressure sensor 1 supplies a pressure signal Sp based on atmospheric pressure to the 0-m reference measuring circuit 3 which in turn amplifies the pressure signal Sp, changes it into a numerical value and supplies a zero reference signal Ddz to the measurement arithmetic processing circuit 10. The measurement arithmetic processing circuit 10 stores this zero reference signal Ddz as a reference value for a water depth of 0 m.

Now, when the diver on an airplane or the like touches the water detection switch 6 with his sweaty hand or the like at the time of a more than 1,000 m descent of the airplane while reference measurement of a water depth of 0 m is carried out every 5 minutes as shown in FIG.2, the measurement arithmetic processing circuit 10 supplies a water depth value Ddpt of more than 1 m to the water depth judging circuit 5 after a predetermined time (0.5 second in FIG. 2) as described above. As the result, the water depth judging signal Dj1 is supplied to the timing circuit 7. After 0.5 second, the water detection switch sample signal Dct is output from the timing circuit 7 and the water detection switch-on detection circuit 8 checks the input state of the water detection switch 6. When the the water detection switch 6 is off, the water detection switch-on detection circuit 7 does not output a water depth mode signal Ddv. Since the display circuit 11 selects a time signal Dtm, the display means 13 continues to display time. (When the water detection switch-on detection circuit 8 detects that the input state of the water detection switch 6 is on, it outputs a water depth mode signal Ddv, thereby the display circuit 11 selects a water depth value Ddpt, and the display means 13 displays a water depth value.) The water detection switch-off count circuit 9 begins to count the off state of the water detection switch 6. Even if the mode is shifted to a water depth measurement mode by mistake, as the water detection switch 6 remains off when the diver is not under water, the water detection switch-off count circuit 9 continues to count the off state of the water detection switch 6. When the water detection switch-off count circuit 9 counts the off state of the water detection switch 6 a predetermined number of times, for example, 256 times, it outputs a cancel signal Dcn to the timing circuit 7. Then the timing circuit 7 stops the output of a water depth measurement start signal Dpd and a water detection switch sampling signal Dct. The water depth measurement operation is thereby cancelled and the water detection switch-on detection circuit 8 is reset. As the result, the water detection switch-on detection circuit 8 stops the output of a water depth mode signal Ddv and switches the display signal Ddsp of the display circuit 11 to a time signal Dtm and returns it to a time display mode.

As described above, in this embodiment, when the water detection switch-on detection circuit 8 counts the on state of the water detection switch 6 once, the mode is shifted to a water depth measurement mode. This increases the chances of shifting to the water depth measurement mode by mistake. To prevent this, the number of times of counting by the water detection switch-on detection circuit 8 should be increased to two or three. However, in this case, shift to a water depth measurement mode takes several seconds in normal operation when the diver goes under water, which deteriorates the ease of use. When the number of times of counting by the water detection switch-on detection circuit 8 is one, the mode can be shifted to a water depth measurement mode with a delay of only 0.5 second.

FIG. 3 is a flow chart explaining the operation of the first embodiment shown in FIG. 1.

When the electronic watch having a water depth measuring function is above water, the display means 13 displays time (S-1). At this point, the timing circuit 7 checks the state of the water detection switch 6 (S-2). When it is on, the timing circuit 7 outputs a water depth measurement start signal Dpd to start water depth measurement (S-3). The timing circuit 7 further checks the state of the water detection switch 6 (S-4). When it is off, the timing circuit 7 stops the output of a water depth measurement start signal Dpd and a time display mode returns (S-1). In the checking step (S-4), when the water detection switch 6 is on, the timing circuit 7 checks if a water depth judging signal Dj1 is output from the water depth judging circuit 5, that is, the water depth exceeds a predetermined value (S-5). When the water depth judging signal Dj1 is output, the timing circuit 7 supplies a water detection switch sampling signal Dct to the water detection switch-on detection circuit 8 and the water detection switch-off count circuit 9. The water detection switch-on detection circuit 8 checks the state of the water detection switch 6 at a timing of the water detection switch sampling signal Dct (S-6). When the state is on, the water detection switch-on detection circuit 8 outputs a water depth mode signal Ddv, changes the display of the display means 13 to water depth measurement display and brings the electronic watch having a water depth measuring function into a water depth measurement mode (S-7). When the state of the water detection switch 6 is off in the checking step (S-6), the output of a water depth start signal Dpd is stopped and a time display mode returns (S-1). In step (S-7) and subsequent steps, the water detection switch-off count circuit 9 checks the state of the water detection switch 6 regularly at a timing of a water detection switch sampling signal Dct. When the state of the water detection switch 6 is off, the circuit counts the number of times of checking the off state of the water detection switch 6 (S-8). When the count number reaches 256 (S-9), the water detection switch-off count circuit 9 outputs a cancel signal Dcn and as the result, the output of a water depth mode signal Ddv from the water detection switch-on detection circuit 8 and the output of a water depth measurement start signal Dpd from the timing circuit 7 are stopped and a time display mode returns (S-1).

As described above, in this embodiment, even when the water detection switch 6 detects by mistake water contact caused by perspiration and further when the mode is shifted to a water depth measurement mode by the water depth judging circuit 5 which detects a water depth value above a predetermined value which is caused by a drastic change in atmospheric pressure due to nose diving of the airplane, the electronic watch is controlled such that the state of the water detection switch 6 is detected and the mode returns to a time mode when the state of the water detection switch 6 remains off for a predetermined time. Therefore, even if the mode is shifted to a water depth measurement

mode by mistake, it is possible to eliminate waste of power consumption and prevents a user from being confused. Further, if the state of the water detection switch 6 is detected to be off right after the detection of a water depth value above a predetermined value, shift to a water depth measurement mode is eliminated. Therefore, shift to a water depth measurement mode caused by erroneous input by the water detection switch 6 can be prevented. Moreover, since the mode is shifted to a water depth measurement mode with only one time of counting the on state by the water detection switch-on detection circuit 8, a swift mode change is possible even when the watch is used in actual diving.

As a consequence, when the user actually dives under water, he/she can use a water depth measuring function without a sense of incompatibility and further can inhibit shift to a water depth measurement mode in the case of the instantaneous erroneous detection of the water detection switch 6. Also, in the case of erroneous shift to a water depth measurement mode, the watch automatically returns a time display mode without a special operation by the diver.

FIG. 4 is a sectional view of an electronic watch having a water depth measuring function according to a second embodiment of the present invention wherein malfunction of the electronic watch is prevented by a structural means.

In FIG. 4, reference numeral 20 represents a water detection terminal which is electrically insulated from a casing 21 connected to a voltage level VDD by packings 22 and 23, installed in a side pipe 24 on the side surfaces of the casing 21, and normally pulled down to a voltage level VSS through an unshown pull-down resistor. Reference numeral 25 denotes a contact spring which is electrically connected to a circuit board 27 of a module 26 of the electronic watch having a water depth measuring function. When the contact spring 25 is press contacted with the water detection terminal 20, the water detection terminal 20 and an unshown water detection circuit on the circuit board 27 are electrically connected. The water detection terminal 20 and the casing 21 are electric conductive through water to detect water contact.

In this embodiment, as shown in FIG. 4, the casing 21 is deeply recessed to contain the water detection terminal 20. Owing to such configuration, even if a user's hand touches a portion near the water detection terminal 20, the water detection terminal 20 is guarded by the casing 21 so that the user cannot touch it. As the result, there is no chance for the user to touch both the water detection terminal 20 and the casing 21 by hand at the same time and as the result, the water detection terminal 20 and the casing 21 are not electrically conductive under conditions other than diving. This makes it possible to prevent erroneous operation of water detection. Further, since the water detection terminal 20 and the casing 21 are electrically conductive through water or sea water when the user actually dives under water, the watch can detect water contact and operates properly.

FIG. 5 is a sectional view of an electronic watch having a water depth measuring function according to a third embodiment of the present invention wherein malfunction of the electronic watch is prevented by a structural means. This embodiment is recited in claim 11. In FIG. 5, the same elements are given the same reference numerals as those of FIG. 4 and their descriptions are omitted.

In this embodiment, as shown in FIG. 5, an insulating member 28 is attached to the surface of the water detection terminal 20. With such constitution, even if a user's hand may touch a portion near the water detection terminal 20, the water detection terminal 20 is covered with the insulating member 28 so that the user cannot touch the water detection terminal 20. Therefore, there is no chance for the user to touch both the water detection terminal 20 and the casing 21 by hand at the same time, and as the result, the water detection terminal 20 and the casing 21 are not electrically conductive under conditions other than diving. This makes it possible to prevent the erroneous operation of water detection. Further, since the water detection terminal 20 and the casing 21 are electrically conductive through water or sea water when the user actually dives under water, the watch can detect water contact and operates properly.

Claims

1. An electronic watch having a water depth measuring function, comprising time signal generation means for generating a time signal, a pressure sensor, a sensor drive circuit for driving said pressure sensor, a water depth measuring circuit for outputting a water depth signal based on the output of said pressure sensor, water depth measurement arithmetic means for generating a water depth value based on the water depth signal, display means for displaying at least one of the time signal and the water depth value, and water detection means for detecting water contact and outputting a water detection signal, wherein the electronic watch further comprises malfunction prevention means for preventing the malfunction of said water detection means.

2. An electronic watch having a water depth measuring function according to claim 1, wherein said malfunction prevention means is systematic malfunction prevention means.

3. An electronic watch having a water depth measuring function according to claim 2 which further comprises circuit operation control means for outputting an operation signal to said water depth measuring circuit upon receipt of the water detection signal from said water detection means and stopping the output of the operation signal when no water detec-

tion signal is supplied from said water detection means after the output of the operation signal.

4. An electronic watch having a water depth measuring function according to claim 3, further comprising a water depth judging circuit for outputting a water depth judging signal when the water depth value exceeds a predetermined value is provided, and a water detection switch detection circuit for outputting a water depth mode signal upon receipt of the water detection sample signal and the water detection signal, wherein said circuit operation control means outputs a water detection sample signal upon receipt of the water depth judging signal.

5. An electronic watch having a water depth measuring function according to claim 4, further comprising a water detection switch-off count circuit for outputting a cancel signal when the absence of the water detection signal is detected during a predetermined time after receipt of the water depth judging signal wherein said water detection switch detection circuit and said circuit operation control means are initialized by the cancel signal.

6. An electronic watch having a water depth measuring function according to claim 5, wherein said display means displays the water depth value when the water depth mode signal is output.

7. An electronic watch having a water depth measuring function according to claim 6, wherein said water depth measurement arithmetic circuit has a reference measuring circuit for measuring a reference value to compute a water depth value, and the operation of said reference measuring circuit is controlled by said circuit operation control means at intervals of a predetermined time.

8. An electronic watch having a water depth measuring function according to claim 7, wherein said circuit operation control means operates said reference measuring circuit when the water detection signal is not output.

9. An electronic watch having a water depth measuring function according to claim 1, wherein said malfunction prevention means is structural malfunction prevention means.

10. An electronic watch having a water depth measuring function according to claim 9, wherein said water detection means has a water detection terminal, and said malfunction prevention means is deeply recessed to contain said water detection terminal.

11. An electronic watch having a water depth measuring function according to claim 9, wherein said water detection means has a water detection terminal, and said malfunction prevention means is an insulating member attached to said water detection terminal.

FIG. 1

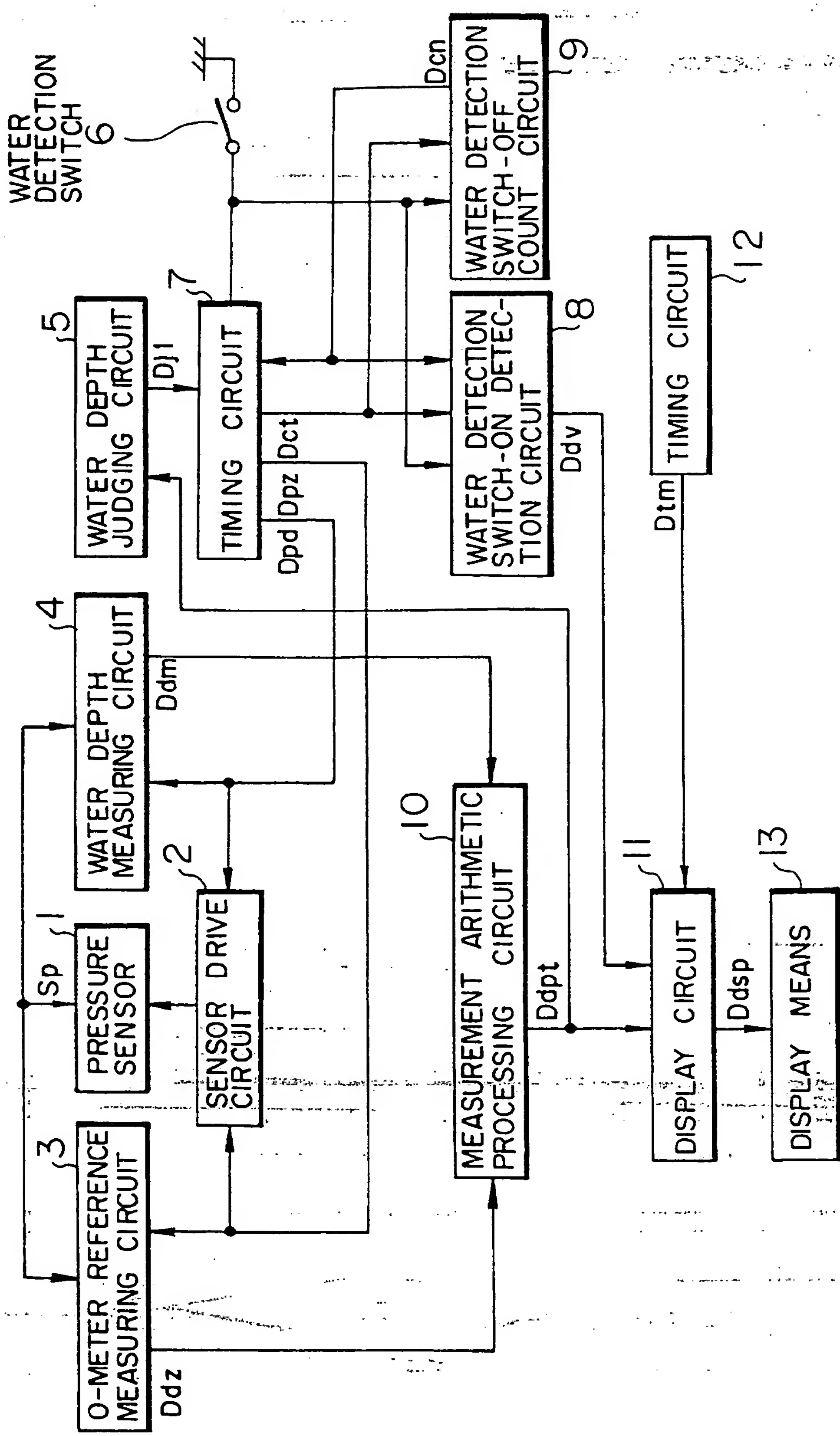

WATER DETECTION SWITCH 6
1 PRESSURE SENSOR
2 SENSOR DRIVE CIRCUIT
3 0-METER REFERENCE MEASURING CIRCUIT
4 WATER DEPTH MEASURING CIRCUIT
5 WATER DEPTH JUDGING CIRCUIT
7 TIMING CIRCUIT
8 WATER DETECTION SWITCH-ON DETECTION CIRCUIT
9 WATER DETECTION SWITCH-OFF COUNT CIRCUIT
10 MEASUREMENT ARITHMETIC PROCESSING CIRCUIT
11 DISPLAY CIRCUIT
12 TIMING CIRCUIT
13 DISPLAY MEANS
Sp
Ddz
Ddm
Djl
Dpd
Dpz
Dct
Dcn
Ddv
Dtm
Ddpt
Ddsp

FIG. 2

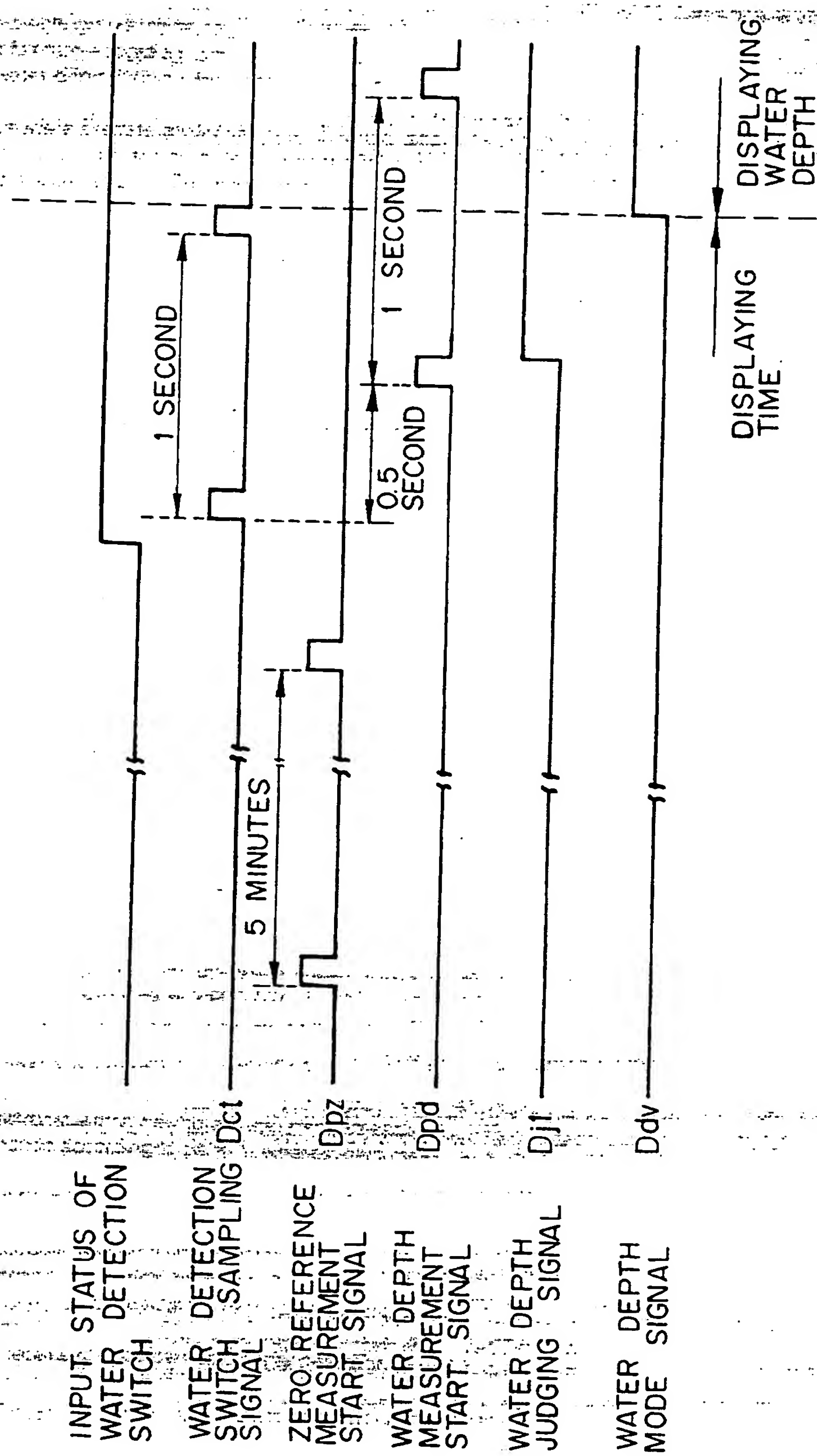

INPUT STATUS OF WATER DETECTION SWITCH
WATER DETECTION SWITCH SAMPLING SIGNAL Dct
ZERO REFERENCE MEASUREMENT START SIGNAL Dpz
WATER DEPTH MEASUREMENT START SIGNAL Dpd
WATER DEPTH JUDGING SIGNAL Djl
WATER DEPTH MODE SIGNAL Ddv
5 MINUTES
1 SECOND
0.5 SECOND
1 SECOND
DISPLAYING TIME
DISPLAYING WATER DEPTH

FIG. 3

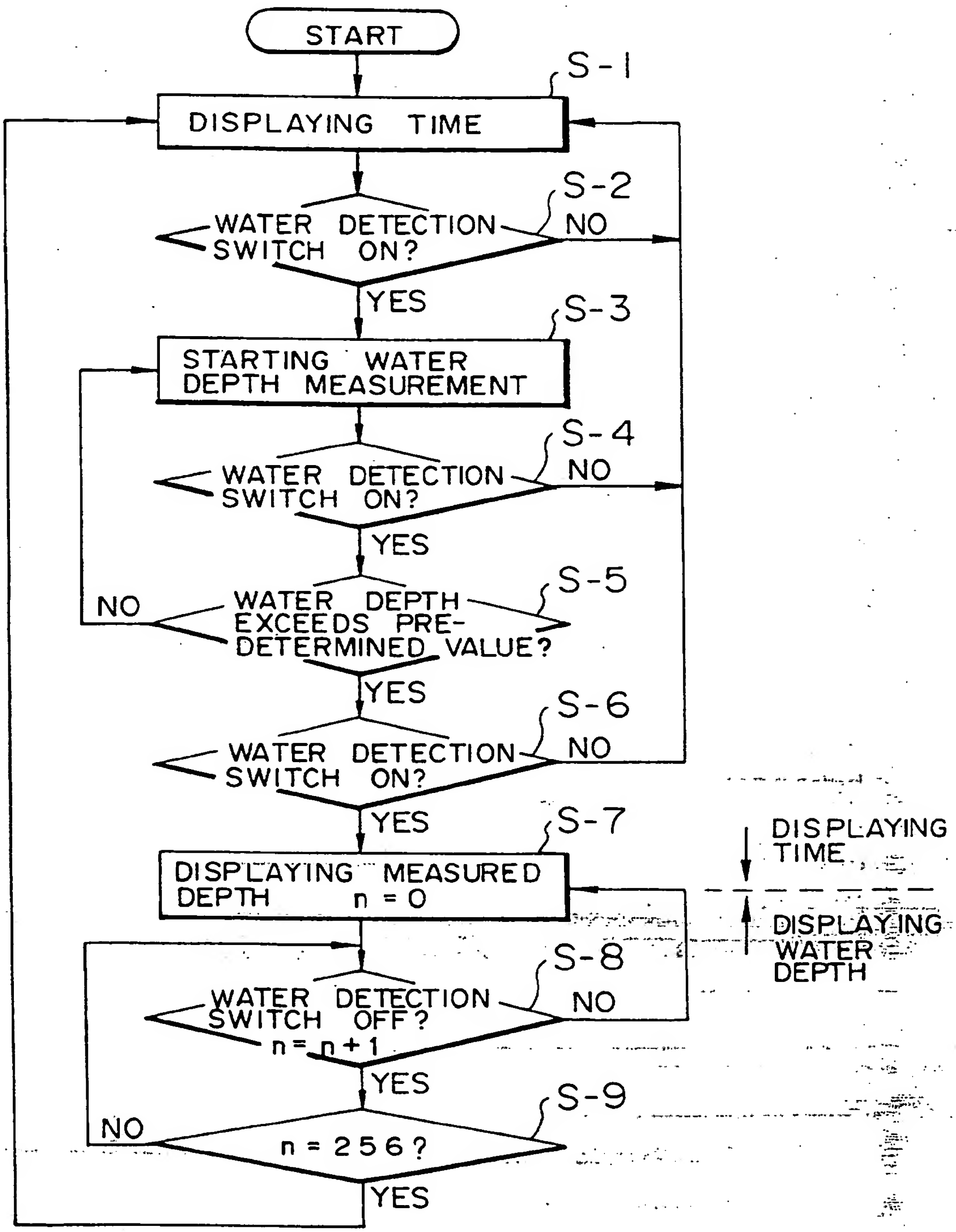

START
S-1
DISPLAYING TIME
S-2
WATER DETECTION SWITCH ON?
NO
YES
S-3
STARTING WATER DEPTH MEASUREMENT
S-4
WATER DETECTION SWITCH ON?
NO
YES
S-5
WATER DEPTH EXCEEDS PRE-DETERMINED VALUE?
NO
YES
S-6
WATER DETECTION SWITCH ON?
NO
YES
S-7
DISPLAYING MEASURED DEPTH n = 0
S-8
WATER DETECTION SWITCH OFF? n = n + 1
NO
YES
S-9
n = 256?
NO
YES
DISPLAYING TIME
DISPLAYING WATER DEPTH

FIG. 4

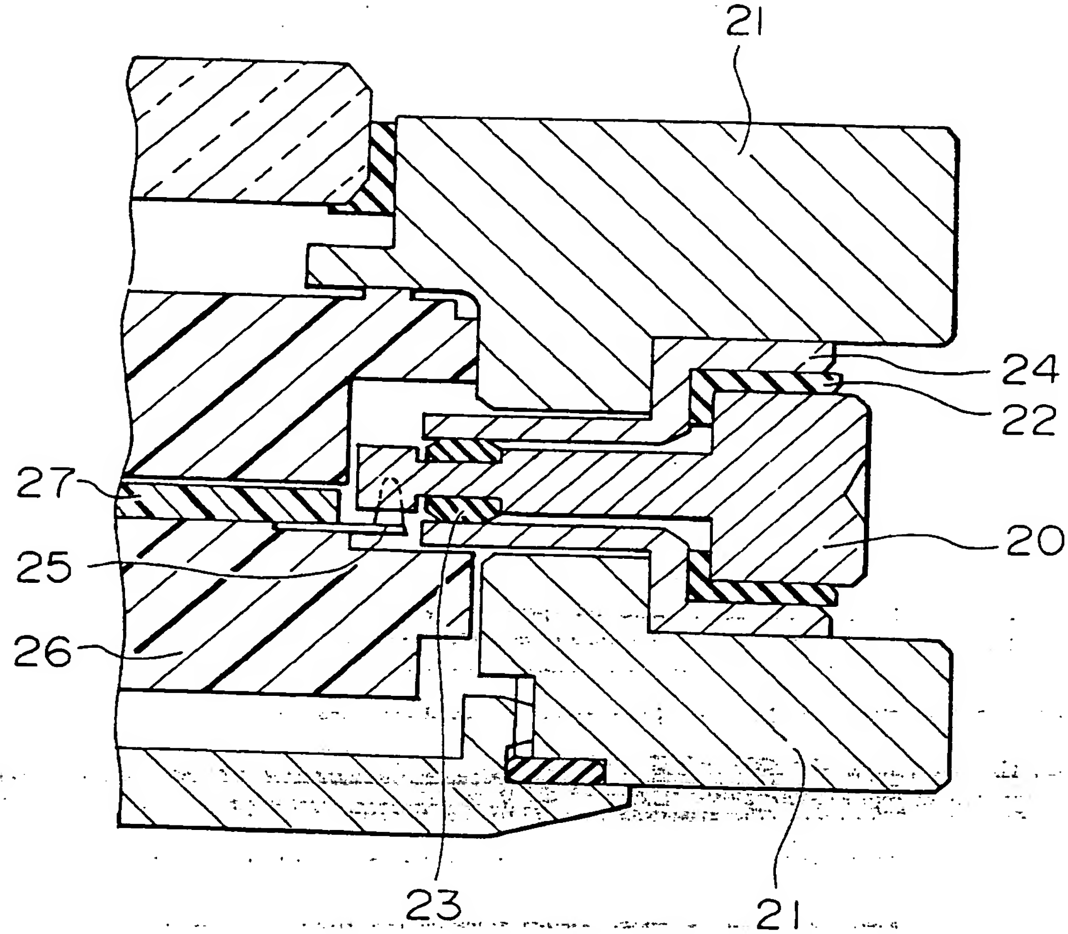
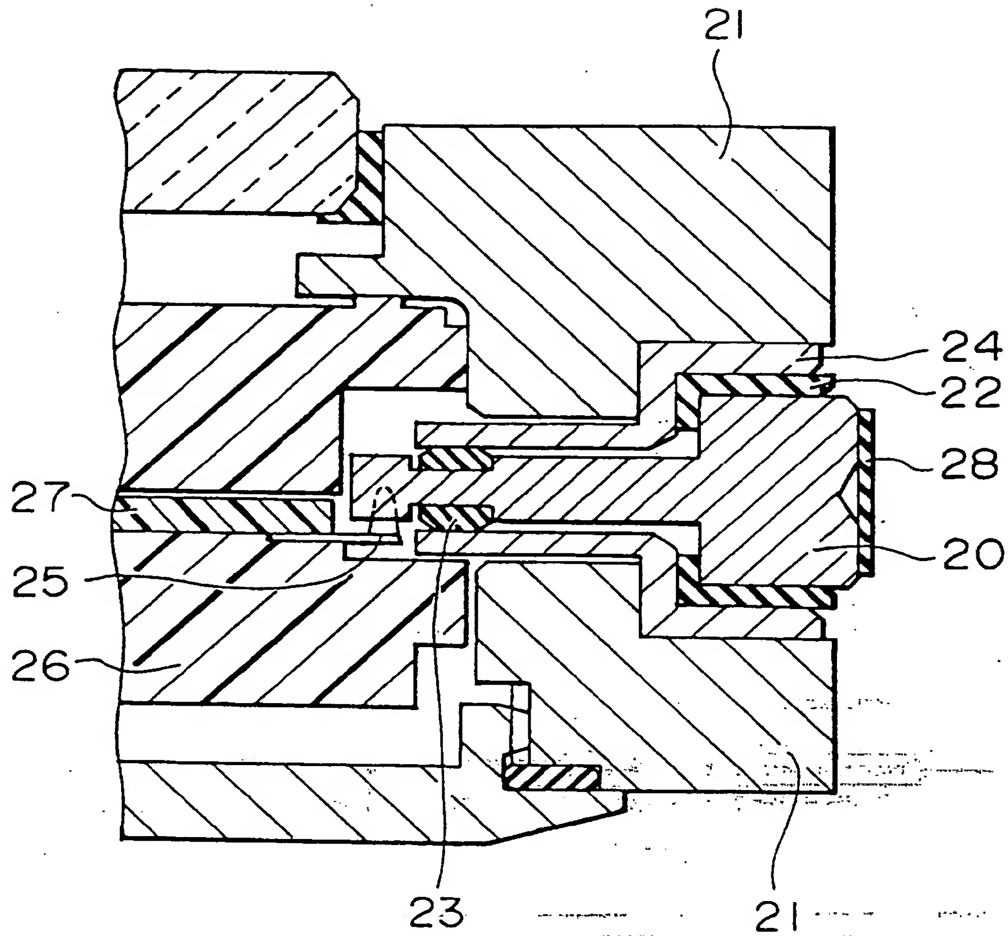


FIG. 5



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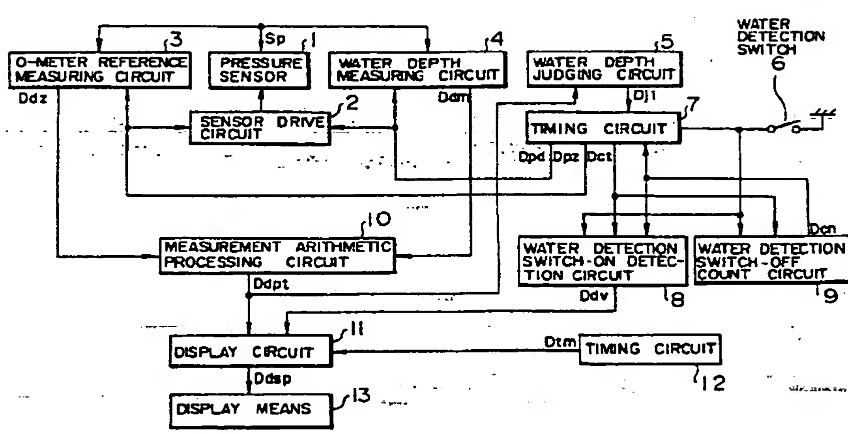
(54) Electronic watch having a water depth measuring function

(57) The present invention is aimed to propose a method for minimizing erroneous shift to a water depth measurement mode by judging whether shift to a water depth measurement mode is caused by normal operation or erroneous detection and for automatically getting out of the water depth measurement mode even in the case of erroneous shift to the water depth measurement mode. Instantaneous shift to a water depth measurement mode is prevented when the water depth judging circuit 5 judges that a water depth value Ddpt from the measurement arithmetic processing circuit exceeds a predetermined value and that the water detection switch 6 detects no water contact, and a time information display mode is automatically returned even in the case of erroneous shift to a water depth measurement mode. Instantaneous shift to a water depth measurement mode is prevented when the water detection switch is on under conditions other than diving, and an original mode is automatically returned by judging the situation precisely even in the case of unexpected shift to a water depth measurement mode.

FIG. 1



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U.M. KOKAI (Japanese Unexamined Utility Model Publication) No. 60-183896

Title of the Invention: Portable Electronic Apparatus with Bathometer

Publication Date: December 6, 1985

U.M. Application No. 59-71140

Filing Date: May 16, 1984

Applicant: Suwa Seikosha Co., Ltd.

CLAIM:

An electronic apparatus with bathometer configured of a water depth sensor for converting at least a water depth value into an electrical signal, a sensor drive circuit for driving said water depth sensor, a signal processing circuit for converting the electrical signal from said water depth sensor into the desired measurement signal, a display unit for displaying a water depth value based on the signal from said signal processing circuit, a power supply, a switch for securing electrical conduction between said power supply and said water depth sensor, said sensor drive circuit and said signal processing circuit, a case for covering said elements from the outer periphery thereof, and cover glass located above said display unit and built integrally into said case; said electronic apparatus with bathometer being characterized by further comprising at least one transparent electrode formed on the inner surface of said cover glass, a detection circuit for detecting that said Cover glass ~~transparent electrode~~ is in contact with water or sea water, a subswitch made of a conductive member for electrically connecting said transparent electrode and said detection circuit to each other, and control means for controlling the water depth measurement

function based on the signals from said switch and said subswitch.

DETAILED DESCRIPTION OF THE INVENTION

[Technical Field]

The present invention relates to lengthening the battery life and improving the practical operability of a portable electronic apparatus having a water depth measurement function.

[Prior Art]

Fig. 1 is a block diagram showing a configuration of a watch having the water depth measurement function as an electronic watch constituting a typical example of a portable electronic apparatus.

In the drawing, the portion defined by the dotted line represents a basic configuration for water depth measurement. The measurement of the water depth usually utilizes the fact that the water depth value and the pressure (about 10 m per atmospheric pressure) are linearly related with each other. For this purpose, a pressure sensor is used. In the drawing, 1 designates a pressure sensor, 2 a drive circuit for driving the pressure sensor, and 3 a signal processing circuit for processing the signal from the pressure sensor. A water depth measuring circuit and a clock circuit 4 are basically independent except that the signal is partially supplied from the clock circuit to the signal processing circuit. Numeral 5 designates a display unit for displaying the water depth value, the time, etc. In the case where the water depth is measured, a switch 6 is turned on. In the case where the water depth is not measured, on the other hand, the switch 6 is turned off.

If a diver who submerges in the water turns on the switch 6 to measure the water depth, then the pressure sensor drive

circuit 2, the pressure sensor 1 and the signal processing circuit 3 are activated. When the diver finishes the submersion and turns off the switch 6 to stop the measurement of the water depth, on the other hand, the pressure sensor drive circuit 2, the pressure sensor 1 and the signal processing circuit 3 are deactivated.

In an actual case of operation, however, the switch 6 is rarely turned on immediately before submersion, or rarely turned off immediately after the end of submersion. Before submersion, the diving equipment is worn after the switch 6 is turned on. In order to adjust himself to the water temperature, the diver may stay for some time on the water surface. Immediately after the end of submersion, on the other hand, the diver turns off the switch after rising to the water surface and coming aboard a ship or reaching the land. The switch may be turned off after taking off the diving equipment.

Especially at the end of submersion, the diver may forget to turn off the switch and a unnecessary measurement of water depth may continue before the diver notes of the fact.

As described above, the unnecessary measurement time is considerably lengthened in actual cases of use. As understood from Fig. 1, on the other hand, a power supply 7 is shared by the water depth measuring circuit and the clock circuit. A small cell such as the silver cell or the lithium cell is used as a power supply for a compact portable equipment such as the watch for the dimensional reason. The cell capacity, therefore, is necessarily limited. The current consumed by the clock circuit is normally 0.5 to 3 μA, while the water depth measuring circuit consumes the current on the order of mA. Thus, the unnecessary water depth measurement is liable to shorten the cell life considerably.

Also, the constant need of taking care to turn on or off the switch is a great disadvantage in actual applications.

[Object]

The present invention is intended to obviate the above-mentioned disadvantages, and the object thereof is to provide a portable electronic apparatus with bathometer in which the water depth measuring circuit is driven only during the actual submersion to eliminate both the unnecessary current consumption and the need of taking special care to turn on or off the switch.

[Outline]

The portable electric apparatus with bathometer according to this invention, in addition to a main switch 6, is configured of at least one transparent electrode formed on the inner surface of the cover glass, detection means for detecting that water or sea water is in contact with the transparent electrode, and a subswitch made of a conductive member for electrically connecting the transparent electrode and the detection means to each other, and characterized in that the function of measuring the water depth is controlled based on the signals from the main switch and the subswitch so that the water depth is measured only during the submersicn.

[Embodiments]

This invention will be explained in detail below with reference to embodiments.

Fig. 2 shows a sectional structure of an electronic watch with water depth measurement function as an embodiment of the invention. In the drawing, 8 designates cover glass, 9 a transparent electrode formed on the inner surface of the cover glass, 10 a movement, 11 a metal exterior case, 12 a display unit, 13 a contact spring for grounding the exterior case to

V_{DD}, 14 a conductive member for fixing the cover glass 8 and the exterior case 11 to each other while at the same time securing water proofness, 15 a conductive member for electrically connecting the transparent electrode and the detection circuit located in the movement 10 for detecting that water or sea water is in contact with the watch, 16 a metal back lid, and 17 a packing.

During submersion using a watch with the water depth measurement function having this structure, as shown in Fig. 3, the contact between the metal exterior case of the cover glass and water or sea water forms a capacitor including the transparent electrode 9 and the cover glass surface as both poles and the glass as a dielectric material. In the process, the capacitance is the generated capacitance C shown in Fig. 3. One electrode of the capacitance C is connected to the conductive member 15, and the other electrode thereof to the metal exterior case 11 through water or sea water.

Fig. 4 shows a switch circuit for the water depth measuring circuit according to the embodiment shown in Fig. 2. In the drawing, 11 designates a metal exterior case connected to V_{DD} through a contact spring (13 in Fig. 2). Numeral 9 designates a transparent electrode. Numeral 19 designates the generated capacitance C described above with reference to Fig. 3. The transparent electrode is connected to a resistor Ra through a conductive member (15 in Fig. 2).

Numeral 6 designates a main switch. One end of the main switch 6 is connected to V_{DD}, while the other end is connected to V_{SS} through a resistor Ra on the one hand and input to an anti-chattering circuit 20 on the other hand. Numerals 21, 22, 23 designate inverters, and the resistor R is connected between the inverters 21 and 23. Numeral 24 designates a NOR

gate, the output of which is applied to the reset terminal of the D-flip-flops 25, 26 and the set terminal of the R-S flip-flop 27. Numeral 28 designates a clock signal output from the clock circuit, which clock signal is input to the clock terminal of the D-flip-flop 25 and the inverters 21, 23. Numeral 29 designates an AND gate supplied with the inverted output of the R-S flip-flop and the output of the anti-chattering circuit. The output of the AND gate 29 is input to the N-channel transistor 32 through the N-channel transistor 30 and the inverter 31. Numeral 33 designates a water depth measuring circuit.

Next, the operation will be explained with reference to the timing chart shown in Fig. 5. In Fig. 5, (a) is an output of an anti-chattering circuit 20, (b) the clock signal 28 in Fig. 4, (c) the output signal of the inverter 22, (d) an input signal of the inverter 23, (e) an output signal of the inverter 23, (f) an output signal of a NOR 24, (g) an output (Q) signal of the D-flip-flop 25, (h) an output (Q) signal of the D-flip-flop 26, (i) an inverted output (/Q) signal of the R-S flip-flop 27, and (j) an output signal of the AND gate 29.

When the main switch 6 in off state, the output (a) of the anti-chattering circuit turns digitally to low level (hereinafter referred to as "L", while the high level will be referred to as "H"). Thus, the output (j) of the AND gate 29 turns "L", so that the N-channel transistor 30 turns off and the N-channel transistor 32 turns on, thereby preventing the water depth measuring circuit from being activated.

Next, assume that the main switch 6 has been turned on. Before the actual submersion starts (at the timing t_1 shown in Fig. 5), the metal exterior case and the cover glass do not come into contact with water or sea water, and therefore,

there is no generated capacitance C'. In this case, the input signals (c), (e) to the NOR gate 24 are inverted from each other (the phases thereof being designed to shift by 180° in this case), so that the output (f) of the NOR gate 24 turns "L". Thus, the D-flip-flops 25, 26 perform the normal frequency dividing operation, and the output (i) of the R-S flip-flop 27 is "L". As long as the output of the R-S flip-flop 27 remains "L", the output (j) of the AND gate 29 also becomes "L". Then, the N-channel transistor 30 turns off and the N-channel transistor 32 turns on, so that the water depth measuring circuit is not activated. In other words, even in the case where the main switch is in on state, the subswitch remains off and the water depth measuring circuit 33 is not activated before the actual submersion starts.

Next, assume that actual submersion has started (at timing t_2 in Fig. 5). At the same time, the metal exterior case and the cover glass come into contact with the sea water, so that a capacitance C' (19 in Fig. 4) is generated with the transparent electrode 9 and the surface of the cover glass as the two electrodes and the glass as a dielectric material. In this case, the input (d) of the inverter 22 assumes a waveform affected by the charge/discharge with the time constant of CR. As a result, the output waveform (e) of the inverter 23 is delayed in phase behind the inverted output waveform (c) of the inverter 22. When the waveforms (c) and (d) are input to the NOR 24, the output (f) assumes a periodical signal assuming a "H" level only during the time delayed in phase. This output (f) is input to the set terminal of the D-flip-flops 25, 26 and the R-S flip-flop 27. At this time, the output (i) of the R-S flip-flop 27 turns "H". Once the output of the R-S flip-flop 27 turns "H", the output (j) of the AND

gate 29 also turns "H". Thus, the N-channel transistor 30 turns on, while the N-channel transistor 32 turns off, thereby activating the water depth measuring circuit 33.

Specifically, the water depth measuring circuit is not activated before the submersion actually starts.

In the process, the time lag Δt_2 in Fig. 5 from the start of submersion by contact with water or sea water to the activation of the water depth measuring circuit is about 2 msec in maximum when the frequency of the clock (b) is 512 Hz, and is considered to have substantially no effect on the operating accuracy.

Next, assume that the submersion ends and the diver has floated up to the water surface or the sea water surface (at timing t_3 in Fig. 5). In this case, the metal exterior case and the cover glass are electrically disconnected from each other, and the generated capacitance C dies out. At the same time, the input signals (c), (e) to the NOR gate 24 are inverted from each other again, and the output (f) of the NOR gate 24 turns "L". Thus, the output (j) of the AND gate 29 also turns "L", and the N-channel transistor 30 turns off, while the N-channel transistor 32 turns on, thereby deactivating the water depth measuring circuit.

Specifically, even in the case where the main switch is in on state, the water depth measuring circuit is deactivated immediately after the end of the submersion. The time lag (Δt_2 in Fig. 5) from the end of submersion to the deactivation of the water depth measuring circuit is about 3 msec in maximum in the case where the frequency of the clock (b) is 512 Hz. During this time, the apparatus is driven wastefully, but the cell life is not substantially affected.

[Effects]

As described above, according to this invention, in addition to the main switch, a subswitch with the detection means for detecting that the cover glass and the exterior case are in contact with water or sea water is provided, and based on the signals from the main switch and the subswitch, the water depth measuring circuit is controlled. In this way, the water depth measuring circuit is activated only during the submersion. As a result, the unnecessary water depth measurement is eliminated, and the limited cell capacity can be effectively used. Also, once the main switch is turned on, the water depth measuring operation is automatically started and stopped. Therefore, it is not necessary to take special care to turn on or off the switch, thereby remarkably improving the practical operability.

As described above, the effects of the present invention are significant.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing a configuration of a watch with the water depth measurement function.

Fig. 2 is a diagram showing the sectional structure according to an embodiment of this invention.

Fig. 3 is a diagram showing the capacitance C generated with the transparent electrode formed on the inner surface of the cover glass and the cover glass surface as both poles and with the glass as a dielectric material.

Fig. 4 is a diagram showing the connections around the switch circuit in a circuit configuration according to the embodiment of the invention shown in Fig. 2.

Fig. 5 is a diagram showing a timing chart for the circuit shown in Fig. 4.

1......Pressure sensor

2......Pressure sensor drive circuit

3......Signal processing circuit

4......Clock circuit

5......Display unit

6......Main switch

7......Power supply

8......Cover glass

9......Transparent electrode

10......Movement

11......Exterior metal case

12......Display unit

13......Contact spring

14......Insulating member

15......Conductive member

16......Back lid

17......Packing

18......Water or sea water

19......Generated capacitance C

20......Anti-chattering circuit

21......Inverter

22......Inverter

23......Inverter

24......NOR

25......D-flip-flop

26......D-flip-flop

27......S-R flip-flop

28......Clock signal

29......AND gate

30......N-channel transistor

31......Inverter

32......N-channel transistor

33......Water depth measuring circuit

(Fig. 1)

2 Pressure sensor drive circuit

1 Pressure sensor

3 Signal processing circuit

4 Clock circuit

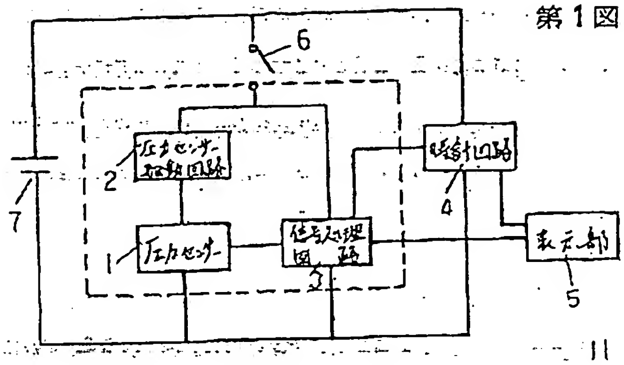
5 Display unit

(Fig. 4)

20 Anti-chattering circuit

33 Water depth measuring circuit

第1図



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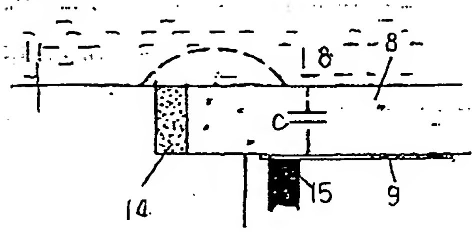

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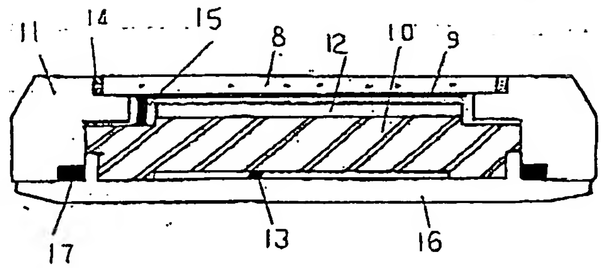

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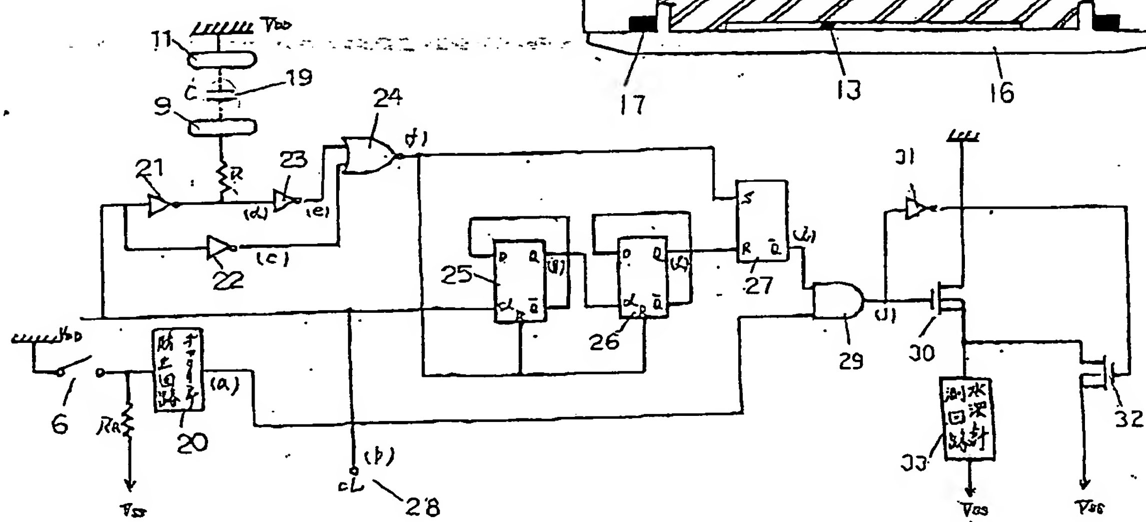

第5図